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Ecosystem Services from Riparian Areas:

A Brief Summary of the Literature

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A riparian buffer is an area of trees and other vegetation adjoining and up gradient from surface water bodies. These buffers may intercept or influence surface runoff, wastewater, subsurface flow, and deeper ground water flows from upland sources there by reducing the movement of associated nutrients, sediments, organic matter, pesticides and other pollutants into surface water and ground water recharge areas (Welsch 1991). Riparian habitats yield a range of ecosystem and human services including both those with use values as well as others with non-use values (Holmes et al., 2004). The benefits with use value arise from in-stream uses (such as fishing, swimming or boating); withdrawal for drinking and irrigation; flood mitigation; enhanced aesthetics; consumptive activities such as hunting; and non-consumptive activities such as bird watching. Riparian systems also provide non-use values such as future benefits (bequest value) and intrinsic values such as the knowing that a healthy ecosystem exists.

Studies have shown that riparian buffers located down slope from agricultural fields can significantly reduce the amount of agricultural pollutants entering streams (Lowrance et al., 1984; Lowrance et al., 1985; Peterjohn et al., 1984; Jacobs and Gilliam, 1985; Schultz et al., 1995). However, Mankin et al (2005) stated that the effectiveness of filter strips to mitigate water quality will be greatly reduced in areas that are tile drained since large amounts of water, and the sediment and nutrients it carries, completely by-pass the filter strips (Cooper et al 1986, Osborne and Kovacic 1993).

Riparian areas, by virtue of their location between uplands and receiving waters, buffer the influx of water and associated constituents from uplands to surface waters to varying degrees in space and time. Riparian areas and waters also have their own interactions. For example, floods can harvest copious amounts of the rich riparian vegetation to receiving waters (e.g., Krug, 2007). And generally wetlands naturally impose organic loading on their adjacent waters with the reducing environment of these landscape suppling bioavailable reduced nitrogen and carbon to water and methane gas and various oxides of nitrogen to the atmosphere (Ruttner, 1974; Thurman, 1985; Stevenson and Cole, 1999) that impact ozone and climate (Intergovernmental Panel on Climate Change, 2001).

While we generally think of riparian habitats and the services they provide in terms of rural areas, riparian buffers in urban and exurban areas provide ecosystem services similar to their rural counterparts. In addition to improving water quality, riparian buffers help provide a variety of ecosystem services such as shade, shelter, and food for fish and other aquatic organisms; wildlife habitat; and economic products while visually diversifying a rural or suburban landscape, enhancing the landscapes aesthetically, expanding recreational opportunities, and protecting these landscapes from flood damage (Dosskey et al., 1997, Postal and Carpenter 1997).

Riparian areas provide other benefits including decreasing soil erosion (Castelle, Johnson, and Conolly 1994); storing and recycling of organic matter and nutrients (Barling and Moore 1994); providing habitat and nursery functions for fish and wildlife (Castelle et al., 1994 and Bren 1993); removal of nutrients such as nitrogen, phosphorous and sediment from surface and subsurface flow (Lowrance et al. 1985, Hill 1996, USDA-NRCS 1999); and providing aesthetic quality, scientific and educational opportunities (USDA-NRCS 1999). Riparian buffers and wetlands have also become an important part of the growing scientific study of ecosystem services (see Millennium Ecosystem

Assessment, 2005, Zedler and Kercher 2005), which are frequently measured using environmental benefit indices (EBI) when it is not possible to assign monetary values.

Riparian areas are prime candidates for use as conservation buffers not just in rural, agricultural areas but in urbanizing areas as well. These buffers can take the form of forested buffers (if planted to trees), as vegetative filter strips when planted to a combination of perennial grasses and shrubs, or some combination of graduated plantings starting with grasses further away from the water body and moving through shrubs and trees as the water body is approached.

In Illinois, the State of Illinois recognizes the value of riparian areas and buffer strips throughout "The Illinois Comprehensive Wildlife Conservation Plan and Strategy" (DNR 2006). This document lays out a strategy for enhancing non-game wildlife, particularly various species of concern in the state. Under the "streams campaign" they discuss that many problems with Illinois' streams originate on uplands and at headwaters." One recommended action is the use of buffer vegetation at land-water transitions. To protect, restore, and enhance near-stream and in-stream habitats and processes, one of their recommendations is to restore and manage grassy buffers, wetlands, riparian forests, and flood plains. Increases in statewide forest acreage should emphasize restoring floodplain and riparian corridors, including providing ecological connectivity among forests and other habitat patches. Wetlands, water control structures, stream meanders and buffer vegetation should be used to moderate the velocity of drainage water. Wetlands should be provided with buffer habitats, equal to or greater than wetland size, to protect ecological functions and provide additional habitat for wetland-dependent wildlife.

In all these recommendations, the use of buffers in riparian areas are an important component of a broader strategy to reduce high flows and floods, decrease stream temperatures, provide greater in-stream habitat for aquatic organisms, decrease sedimentation and the input of excess nutrients and contaminants, and provide habitat for wildlife. An important component for wildlife is that these riparian areas provide corridors for transportation between larger blocks of habitat, provide food and shelter, and for some species provide habitat for reproduction. The size of the riparian habitat is important, as is the structure of the vegetation and the species of grasses, shrubs, and trees. Wider riparian corridors can provide a greater diversity of plants and habitats.

With the removal over the last 30 years of many fence-rows and hedge-rows, riparian habitats have become increasingly important as wildlife corridors. Larger blocks of land in projects such as CREP can provide the advantages of near stream buffers, plus additional grassland and forest habitats over a broader area.

More generally speaking, in the Midwest Corn Belt region, riparian forests are often the most sizable natural habitat feature remaining in the landscape (Bretthauer and Edgington 2002), and they are facing increasing development pressure (Iverson et al. 1989). Continuing loss of riparian forest habitat is particularly troublesome in states such as Illinois, where riparian forest fragments are the primary breeding habitat areas available to many wildlife species, and particularly forest songbirds. Riparian forests provide breeding and stopover habitat for many birds, and they typically support a greater richness and higher density of breeding songbirds than the surrounding landscape, including the upland forest (Stauffer and Best 1980; Best et al 1995, Kinley and Newhouse 1997).

Numerous bird species have evolved breeding strategies specific to the unique structure and composition of riparian forest systems. In Illinois such species include the belted kingfisher and wood duck, among others, that are associated directly with streams, and occupy habitats immediately adjacent to the stream channel itself. Other species such as the Acadian flycatcher, and yellow-billed cuckoo are found nesting almost exclusively in the interior, floodplain portions of the forests. Many other generalist bird species can be found nesting in riparian forests as well.

The value of riparian habitat is not, however, limited to songbirds. Riparian vegetation provides food, breeding sites and cover for many wildlife species and is an essential component for maintaining high water quality in streams, which in turn benefits the associated stream wildlife. Studies have shown riparian areas to contain up to twice the number of plant and animal species as adjacent upland areas (Gregory et al. 1991). Many of these plant and animal species are unique to riparian habitat, and numerous other species are dependant on the riparian system for at least a portion of their lifecycle. Additionally, as surrounding landscapes have become more and more disturbed, riparian habitat has become an increasingly important refuge and dispersal corridor for game and predator species such as whitetail deer, coyotes, and wild turkey.

Mankin et al. (2005) did an extensive study in east central Illinois.

of filter strips. What they found were narrow, linear grass areas that were planted adjacent to waterways to intercept pollutants and soil erosion. Average width of these strips was 20m (66ft), and they were composed of warm season or cool season grasses. The value of these strips for grassland birds was marginal. While the authors stated that the number of species using filter strips for food and shelter in the fall was noteworthy, these strips were not sufficient for sustaining grassland fauna and they tend to be ecological traps for nesting birds.

Mammals faired better in these filter strips. The authors stated that a variety of mammals were attracted to the filter strips. Consequently, predators were also drawn to them. Larger mammals appeared to use filter strips as travel lanes or corridors. The various small mammal studies indicate that the widespread adoption of conservation tillage and filter strips has benefitted mammal species such as deer mouse and meso-mammal predators.

Mankin et.al (2005) concluded that “filter strips are likely population sinks for nesting birds, but they do provide birds, mammals, and reptiles with cover and forage opportunities that would not exist if crop fields replaced the filter strips”.

De Groot (1992), classified ecosystem functions into four general categories: (1) regulation function, (2) carrier or habitat function, (3) production function, and (4) information function. The regulation function relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological process and life support systems through bio-geochemical cycles (e.g., carbon cycle) and other biospheric processes (e.g., photosynthesis). The habitat function (carrier function) arises from the ability of an area to provide space and means to satisfy physical needs of humans, flora, and fauna. The information functions arise from the provision of opportunities for enrichment, cognitive development, and recreation afforded by natural ecosystems. The production functions are ecosystem goods that are produced naturally without alteration of natural process by humans, but humans must spend time and energy to harvest the goods. Following de Groot (1992) and his framework of ecosystem function and evaluation, Table 1 summarizes the various functions and services of riparian ecosystem as reported in the literature.

Table 1. Riparian Ecosystem Functions and Services.

Number	Ecosystem Function	Ecosystem Services	Literature
1. **Regulation Function**			
1.1	Gas regulation	Role of riparian ecosystem in bio-geochemical cycles. Provides clean breathable air.	Wilson et al., 2005.
1.2	Climate regulation	Influence of land cover and biological mediated process on climate. Influence terrestrial and stream temperature, human health, recreation and crop productivity. Thermal refuge for aquatic species.	Collier (1995); Wegner (1999); Woodall (1985); Wilson et al., (2005); de Groot et al., (2002). Cunjak (1996) ; Waters (1995).
1.3	Disturbance prevention	Influence of ecosystem structure on dampening environmental disturbances such as, flood attenuation, ice damage control, stream bank stabilization, maintaining channel morphology. Biological control mechanisms	Postal and Carpenter (1997); Fischer and Fischenich (2000); Platts (1981); Wegner (1999); Williams (1986); de Groot (2002).
1.4	Water Regulation	Role of riparian cover in regulating runoff and stream flow. Infiltration and maintenance of stream flow.	Williams (1986); Lowrance et al; (1984).
1.5	Water Supply	Filtering, retention, and storage of fresh water. Riparian buffers filter sediments, nutrients, pathogens, pesticides, and toxics in runoff. Infiltration of surface water that helps maintain baseflow. Water supply and ground water recharge.	Fischer and Fischenich (2000); Waters (1995); Chase (1995); Hartung and Kress (1977); Peterjohn and Correll (1984).
1.6	Soil retention	Role of vegetation root matrix and soil biota in soil retention. Reduce	Waters (1995); Castelle et al.

		soil erosion and sediment control.	(1994);
1.7	Soil formation	Weathering of rock, accumulation of organic matter. Maintenance of top soil and soil fertility.	de Groot (1992).
1.8	Nutrient regulation	Storage and recycling of nutrients such as N and P and organic matter. Contribution of organic matter to stream from adjacent vegetation	Barling and Moore (1994); de Groot (1992).
1.9	Waste treatment	Role of riparian vegetation & biota in removal or breakdown of xenic nutrients and compounds. Storage and recycling of human waste	Castelle et al. (1994); de Groot (1992).
1.10	Pollination	Role of biota in pollination.	de Groot (1992).
2. **Habitat (Carrier) functions**			
2.1	Refugium function	Suitable living space for wild animals and plants. Woody debris in the stream provides habitat and shelter for aquatic organisms. Terrestrial riparian ecosystem provides habitats for amphibians, mammals and birds. Habitat for natural communities, rare threatened and endangered species. Provide travel corridors for migration and dispersal.	Chase (1995); Verry et al. (2000); Allan (1995); Wenger (1991); (2002); Kaufman (1992); Keller et al. (1993); Naiman and Rogers (1997); Hammond (2002).
2.2	Nursery functions	Suitable reproduction habitat for aquatic organisms and amphibians.	Semlitsch (1998); de Groot (1992).
3. Production Function			
3.1	Food	Conversion of solar energy into edible plants and animals.	de Groot (1992). Wilson et al., (2005)
3.2	Raw materials	Conversion of solar energy into biomass for human construction and other uses. Genetic materials.	de Groot (1992). Wilson et al.(2005)
4**. Information Function**			
4.1	Aesthetic	Attractive landscape	de Groot (1992).

	information	features. Clear and clean water enhances sensory and recreational qualities	Wilson et al. (2005)
4.2	Recreation	Water quality for recreation, boating, swimming	de Groot (1992); Wilson et al. (2005)
4.3	Science and education	Variety in nature with scientific and educational value.	de Groot (1992); Wilson et al. (2005)

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